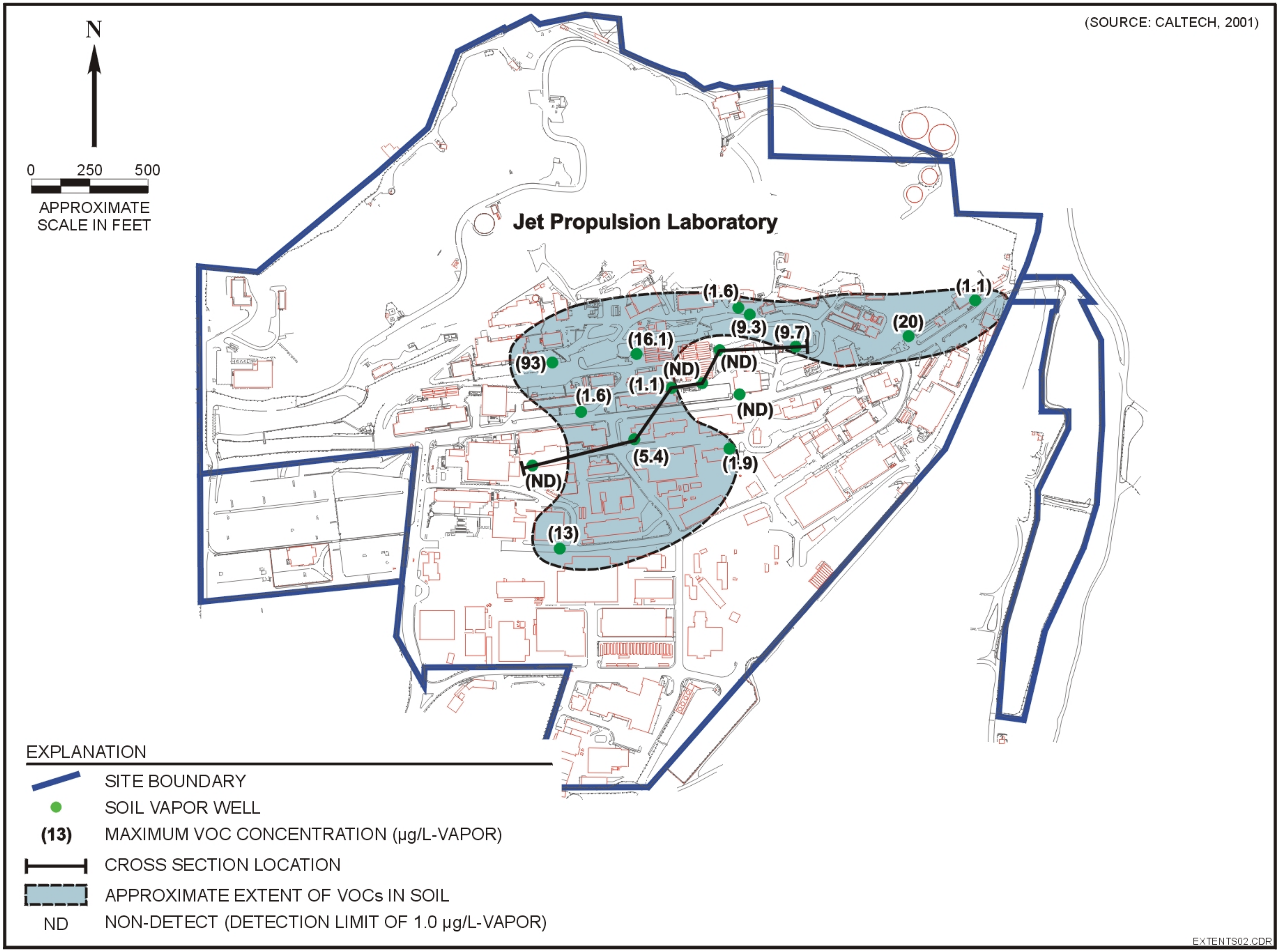

Figure 5-3. Plan View of VOC Soil Vapor Plume (July 2001)

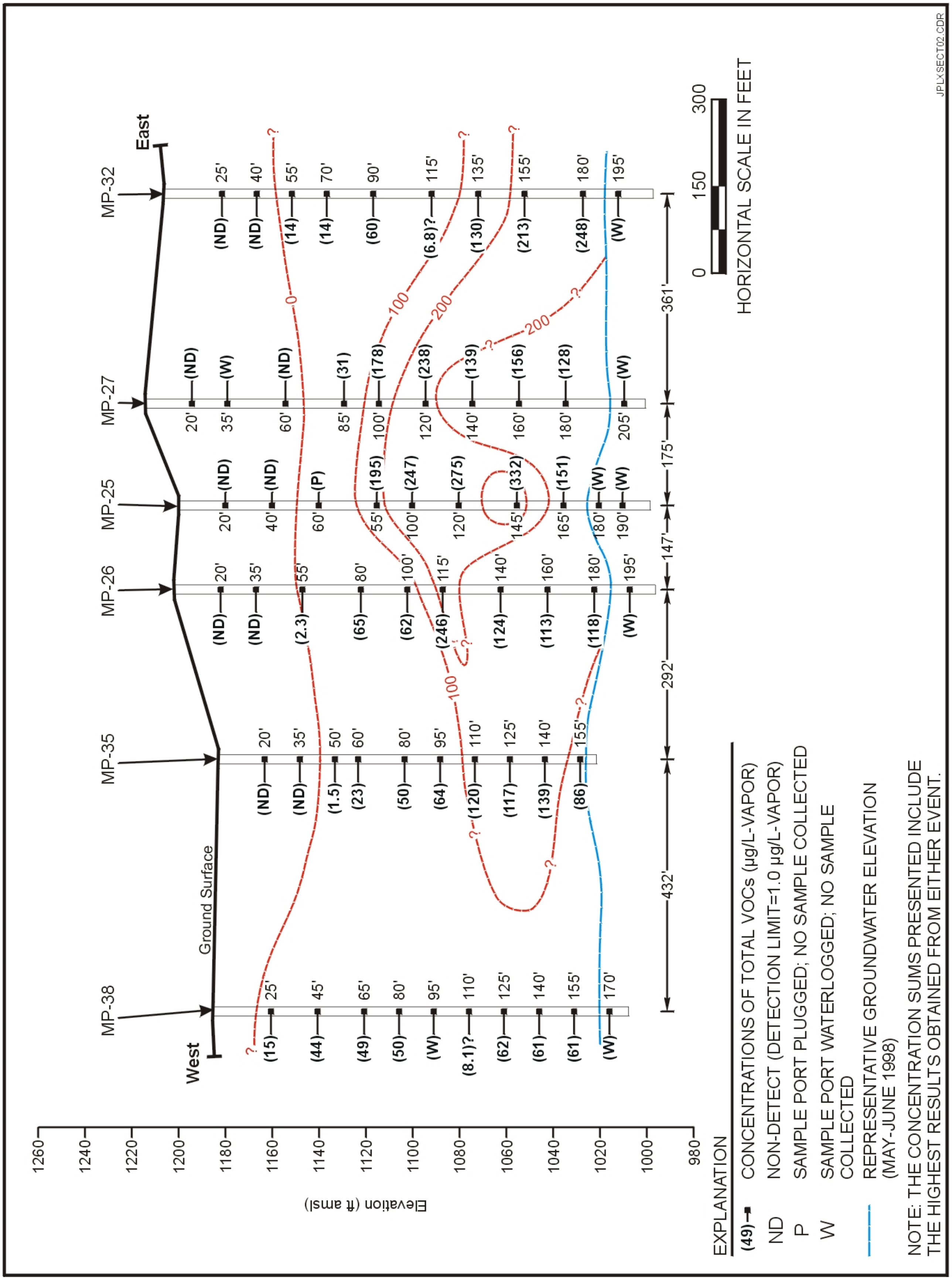

Figure 5-4. Vertical Cross Section of VOC Soil Vapor Plume (May-June 1998)

As part of the FS, the total VOC mass in the vadose zone was estimated to be between 2,250 and 5,040 lbs. These mass estimates were determined using standard equations and simplifying assumptions regarding average VOC concentrations in soil (FWEC, 2000). As part of this ROD, the VOC mass estimates were recalculated using a three-dimensional computer modeling software package, EarthVision™ Volumetrics program, using data from the RI (1996-1998) and more recent data (July 2001). Tables 5-1 and 5-2 summarize the historic (1996-1998) and current (July 2001) range of VOC concentrations in the vadose zone and the revised mass estimates.

Table 5-1. Summary of Historic Soil Vapor Sampling Results (1996-1998)

Chemical	Range of Concentrations (μg/L)	Estimated VOC Mass Remaining in the Vadose Zone[(a)] (lbs)
CCl_4	ND-402	468
DCE	ND-9.8	3
Freon™113	ND-113	113
TCE	ND-47	52
Total VOCs	NA	636

Note: NA= Not Applicable

(a) Mass estimated using EarthVision™ Volumetrics program calculation.

Table 5-2. Summary of Current Soil Vapor Sampling Results (July 2001)

Chemical	Range of Concentrations (μg/L)	Estimated VOC Mass Remaining in the Vadose Zone[(a)] (lbs)
CCl_4	ND-36	9
DCE	ND-3.0	2
Freon™ 113	ND-11	7
TCE	ND-26	27
Total VOCs	NA	45

(a) Mass estimated using EarthVision™ Volumetrics program calculation.

5.2.2 Soil Sampling Results

Soil sampling events, carried out from 1994 to 1998, consisted of collecting samples during drilling and test-pit excavations. Soil samples were analyzed for metals, SVOCs including PAHs, PCBs, dioxins and furans, TPH, tributyltin, cyanide, and nitrate. Only near-surface soil samples from test pits were sampled for VOCs. The use of air percussion drilling techniques, required for the site geology and investigation depths, precluded the sampling of VOCs from soil boring samples. Detailed information regarding the constituents detected in soil is provided in the RI report (FWEC, 1999a). The following subsections summarize soil sampling results.

5.2.2.1 Metals. Where detected, metal concentrations reasonably correlated to the range of background levels measured for soils at JPL, and within the range measured for other California soils. Arsenic was detected (at a maximum concentration of 3 mg/kg) in soil samples at concentrations slightly above measured background values, but well within the naturally occurring range measured for other California soils. Hexavalent chromium was detected (at a maximum concentration of 0.84 mg/kg) at only four sampling locations including Test Pit 1A, Test Pit 2A, Test Pit 3A, and Boring 29 (FWEC, 1999a). These detections were all below the U.S. EPA Region 9 health based action level of 30 mg/kg.

5.2.2.2 Semivolatile Organic Compounds. Four SVOCs from the class of polycyclic aromatic hydrocarbons were detected in vadose zone soil. Bis(2-ethylhexyl) phthalate was detected in seven soil borings and two test pit samples at concentrations ranging from 50 to 1,900 μg/kg and at depths ranging from 1 to 81 ft bgs. Butylbenzylphthalate was detected in one shallow test-pit sample (approximately 1 ft bgs) at a concentration of 160 μg/kg. Di-n-butylphthalate was detected in one shallow test pit sample (approximately 1 ft bgs) at a concentration of 250 μg/kg. Finally, N-nitroso-di-N-dipropylamine was detected in one soil boring at a concentration of 500 μg/kg at a depth of 30 ft bgs. The concentrations of all four SVOCs were below the risk-based, screening toxicity values presented in the FS (FWEC, 1999), which were based on EPA Preliminary Remediation Goals (PRGs) (EPA, 1989, 1991, 1998) and State of California Guidance (DTSC, 1994).

5.2.2.3 PCBs, Dioxins, and Furans. Two PCB mixtures, Arochlor-1254 and Arochlor-1260 were detected in two shallow test pit samples (approximately 1-5 ft bgs) at concentrations up to 200 μg/kg and 270 μg/kg, respectively. Another mixture, Arochlor-1232, was detected at a depth of 5 ft in shallow test pit TP-2A at 33 μg/kg. Maximum Arochlor-1254 and Arochlor-1260 concentrations were above the screening toxicity value of 110 μg/kg; however, the site-specific risk assessment demonstrated that the carcinogenic risk was within the target range of $1x10^{-6}$ to $1x10^{-4}$ (FWES, 1999). The dibenzodioxin, 1,2,3,4,6,7,8,9-OCDD, was detected at concentrations of 5.8 to 9.8 μg /kg in two shallow test pit samples at depths of 1 ft bgs. Concentrations of this dibenzodioxin were below the screening toxicity value of 36 μg /kg. Dibenzofurans were not detected in any of the soil samples collected during the OU-2 RI.

5.2.2.4 Volatile Organic Compounds. Four VOCs (acetone, bromodichloromethane, chloroform, and methylene chloride) were detected in soil samples collected from the shallow test pits constructed during the RI phase of the project. All concentrations were equal to or less than their respective reporting limits. VOC analysis of soil collected from deeper soil borings, rather than shallow test pits, is subject to significant error due to volatile losses experienced during both drilling and sample collection. For this reason, soil vapor VOC levels are used as a surrogate for VOC levels in soil at JPL (see Section 5.2.1). The VOC levels in soil vapor can be used to estimate corresponding VOC soil concentrations and vice versa using standard chemical partitioning equations.

5.2.2.5 Other Compounds. Several other constituents were detected in JPL soils. TPH, possibly associated with lubricating or mineral oils, was detected in 13 soil borings. The maximum TPH levels detected in all but one of the soil borings were less than 150 milligrams per kilogram (mg/kg). TPH detected at a concentration of 6,500 mg/kg in soil boring No. 1 was attributed to tiny asphalt granules in the materials used to backfill the seepage pit (FWEC, 1999). Cyanide was detected in three samples collected from one soil boring at concentrations ranging from 0.074 mg/kg to 0.085 mg/kg. These detections were limited to one location and were well below the residential PRG of 11 mg/kg (U.S. EPA, 1998). Nitrate was detected in virtually all soil borings. The widespread occurrence of nitrate is attributed primarily to the use of fertilizers in landscaped areas of JPL and runoff of irrigation waters. Soil sampling for perchlorate will be conducted during the installation of SVE and soil vapor monitoring wells. Following sampling, the impact of the infiltration and migration of perchlorate from the vadose zone to groundwater will be evaluated.

5.3 Fate and Transport of Chemicals in Soil at JPL

Figure 5-5 is a conceptual model for the transport of VOCs from the JPL seepage pits to the vadose zone and the groundwater. A summary of the potential migration pathways and fate and transport processes for chemicals associated with OU-2 is shown in Figure 5-6. A detailed discussion of these processes with regard to specific site conditions is presented in the OU-2 RI report (FWEC, 1999a).

5.3.1 Fate and Transport of VOCs at JPL

The VOCs detected on-facility were generally characterized as being moderately soluble in water and moderately adsorbing to soil organic carbon. Results from the OU-2 RI (FWEC, 1999a) suggest that migration of VOC vapor to the ground surface and subsequent emission to the atmosphere is not likely. Elevated VOC vapor concentrations are generally found at depths of greater than 20 ft below ground surface (bgs), which suggests the bulk of the VOC-impacted soil is also at depth. The infiltration and percolation of rainfall, which causes vertical downward flow of VOCs from the vadose zone to groundwater, appears to be the principal transport mechanism at JPL. However, the OU-1/OU-3 groundwater data (FWEC, 1999b) suggest that their downward migration is decreasing in significance with time.

5.3.2 Fate and Transport of Other Chemicals in Soil at JPL

Although VOCs have migrated to groundwater, significant migration of other organic compounds (e.g., SVOCs, PAHs) through infiltration and percolation to groundwater has not occurred based on the data available from the OU-2 RI (FWEC, 1999a) and the OU-1/OU-3 RI (FWEC, 1999b). The migration of metals such as arsenic and hexavalent chromium through infiltration and percolation has been documented, but their occurrence in soil and groundwater at JPL is very localized.

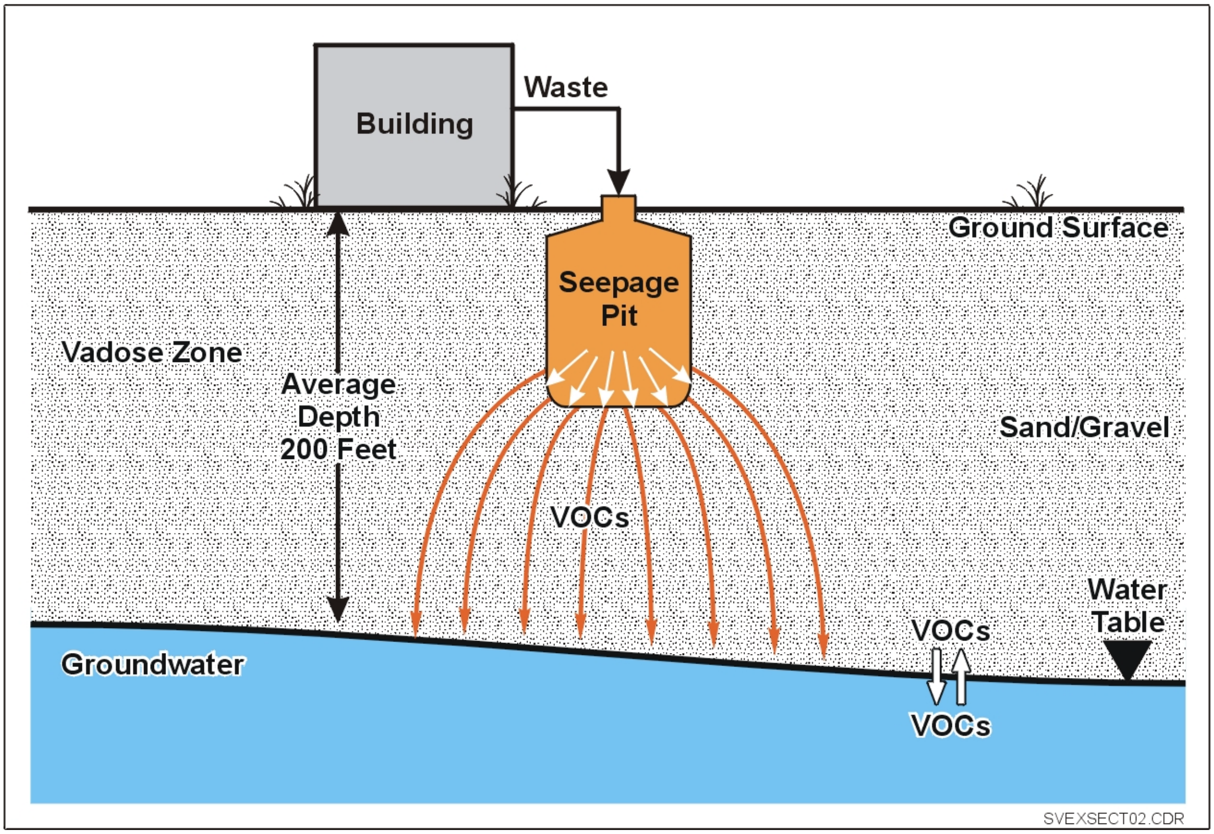

Figure 5-5. Site Conceptual Model for Transport of Chemicals

Stormwater runoff can potentially lead to the migration of chemical constituents in surface soil and sediment to surrounding on- and off-facility receptors, especially during periods of rapid rainfall. However, this migration pathway is insignificant since the majority of JPL is paved and levels of SVOCs, PCBs, metals, and other compounds detected in near-surface soils are below levels of concern (i.e., screening levels or site-specific risk levels).

Erosion and subsequent wind transport of metals, SVOCs, PCBs, and other compounds residing in surface soil and sediment at JPL are considered insignificant because concentrations are generally low, and the affected area is paved.

5.3.2.1 Metals. Arsenic occurs naturally in southern California soils, and arsenic concentrations detected at JPL were within the background range (Kearney, 1996). Arsenic has been detected in groundwater at JPL, but only in a very localized, deep part of the aquifer. During the long-term groundwater monitoring program, levels up to 0.011 mg/L of arsenic were detected at depths of 430 to 908 ft bgs in six monitoring wells at JPL. These arsenic levels are all below the current MCL of 0.05 mg/L and the maximum concentration observed was only slightly above the revised MCL of 0.01 mg/L to be promulgated in 2006. It appears that significant leaching or migration of arsenic from vadose zone soil to groundwater has not occurred and that arsenic levels in soil and groundwater are within acceptable ranges based upon background levels and/or health-based cleanup criteria.

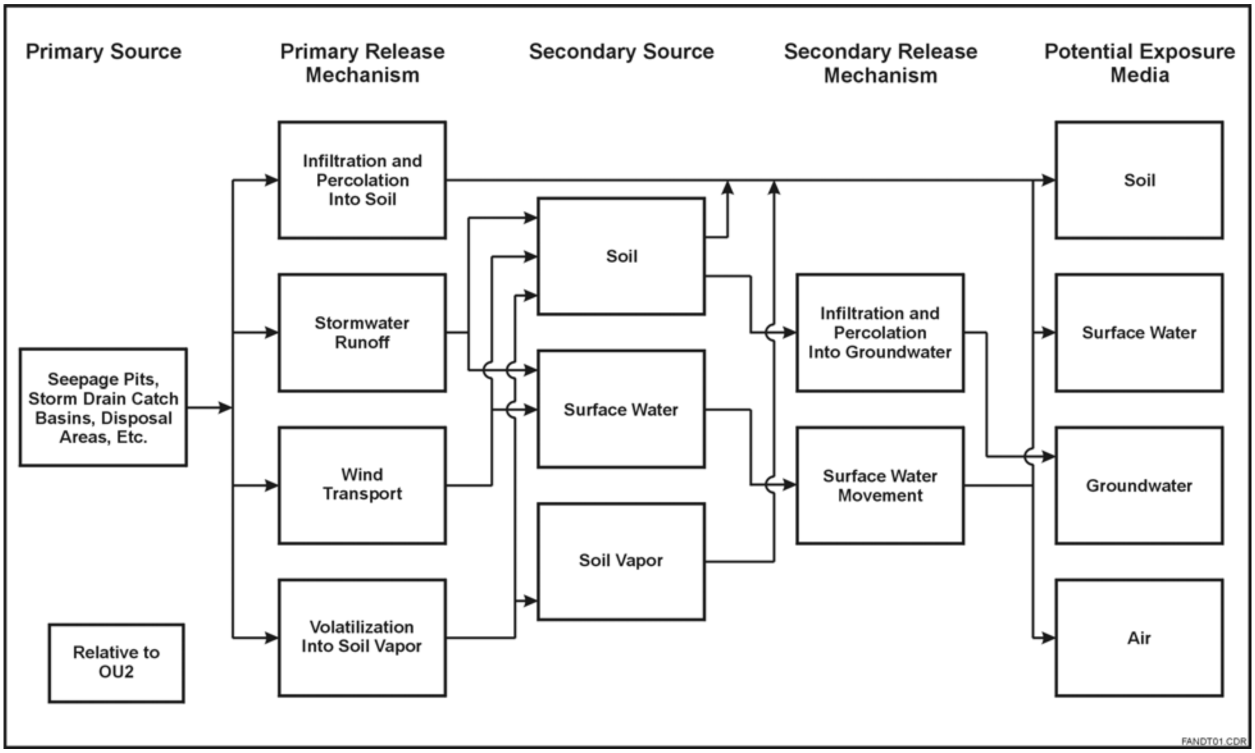

Figure 5-6. Chemical Fate and Transport Conceptual Diagram

Chromium can exist in either a trivalent or hexavalent form. The hexavalent form is more soluble and can be mobilized in soils as water passes through. However, hexavalent chromium was only detected in four soil samples at JPL and the concentrations were all below the health-based action level of 30 mg/kg. During the long-term groundwater monitoring program, hexavalent chromium was detected in six monitoring wells at levels up to 0.047 mg/L and depths of 105 to 476 ft bgs (below the tap water PRG of 0.11 mg/L [EPA, 2001]). The migration or leaching of hexavalent chromium from the vadose zone to groundwater has occurred, however, not above levels of potential concern.

5.3.2.2 Semivolatile Organic Compounds. Volatilization is considered to be of minor concern with regard to PAHs. In addition, because the PAHs detected in soil at JPL have low aqueous solubility and high adsorption potential, they are not expected to leach from soil into groundwater. Results from the OU-2 RI (FWEC, 1999a) and the OU-1/OU-3 RI (FWEC, 1999b) support this assertion because most PAH detections occurred in samples collected from the upper 10 ft of soil and there was no significant evidence of their presence in groundwater. Other SVOCs were detected in soil samples collected near the surface in the vicinity of a suspected waste disposal area. Most have low solubility and low volatilities and are considered relatively immobile in soil-water systems. The infrequency of detections of SVOCs in deeper soil and groundwater at JPL reflects the immobility of these SVOCs.

5.3.2.3 PCBs, Dioxins, and Furans. PCBs are characterized by very low solubility and high affinities for adsorption to soil. Therefore, they are considered to be relatively immobile in soil-water systems. The absence of PCBs and dibenzodioxins in deeper soil and groundwater at JPL reflects their immobility. Potential pathways for PCBs at JPL are most likely limited to wind transport in soil or dust particulates. Potential migration pathways for dibenzodioxins are considered insignificant.

5.3.2.4 Other Compounds. The types of petroleum hydrocarbons present in JPL soils are considered to be relatively insoluble and to adsorb strongly to soil particles. In addition, their tendency to volatilize is weak. Thus, transfer to the atmosphere would be negligible. In addition, petroleum hydrocarbons are subject to biodegradation. Tributyltin compounds are the main active ingredients in bactericides and fungicides used in wood preservatives, marine paints, and industrial water systems. In soil, tributyltin takes one to three months to degrade in aerobic conditions and more than two years to degrade in anaerobic conditions. In soil, cyanide complexes with metals and organic compounds. These complexes vary widely in their chemical properties. Nitrate is readily soluble and mobile in soil, as evidenced by its presence in JPL groundwater. Soil bacteria can reduce nitrate to nitrogen gas under anaerobic conditions, if a suitable carbon source is available.

5.4 Exposure Pathways

For the Human Health Risk Assessment (HHRA), potential exposures to chemicals in vadose zone soil at JPL were quantitatively evaluated for the hypothetical on-facility resident, the commercial worker, and the construction worker. (Note that NASA has no intent to use JPL for residential sites in the foreseeable future. However, NASA based the risk assessments on potential residential use to provide the most conservative and protective results.) Direct exposures through inhalation, dermal contact, and incidental ingestion pathways were evaluated.

For the Ecological Risk Assessment (ERA), chemical exposures were quantitatively evaluated for the deer mouse and the American kestrel. These species were used in the assessment because they generally have the highest exposure because of their diet and bioaccumulation in the food chain.

More information on the results of the HHRA and ERA is included in Section 7.0 of this document and in the RI report (FWEC, 1999a).

6.0: CURRENT AND POTENTIAL FUTURE LAND AND RESOURCE USES

JPL is a NASA-owned facility where the California Institute of Technology (Caltech) performs R&D projects. JPL is the federal government's lead center for R&D related to robotic exploration of the solar system. In addition to NASA work, tasks for other federal agencies are conducted at JPL in areas such as remote sensing, astrophysics, and planetary science.

6.1 Land Uses

JPL comprises about 176 acres of land. Of these 176 acres, about 156 acres are federally owned. The remaining land is leased for parking from the City of Pasadena and the Flintridge Riding Club. Presently, more than 150 structures and buildings occupy JPL. Total usable building space is approximately 1,330,000 ft^2. The main developed area of JPL is the southern half, which can be divided into two general areas, the northeastern early-developed area and the southwestern later-developed area. Most of the northern half of JPL is not developed because of steeply sloping terrain (see Figure 1-1).

Currently, the northeastern early-developed part of JPL is used for project support, testing, and storage. The southwestern later-developed part is used mostly for administrative, management, laboratory, and project functions. Further development of JPL is constrained because of steeply sloping terrain to the north, the Arroyo Seco to the south and east, and residential development to the west.

Located at the northern boundary of JPL is the Gould Mesa area. This area has widely separated, small buildings and is used primarily for antenna testing. The distance between buildings is a result of the terrain and the need to isolate transmitting and receiving equipment. The relatively steep mountainside between Gould Mesa and the developed area at JPL is unpopulated.

The primary land use in the areas surrounding JPL is residential and light commercial. Industrial areas, such as manufacturing, processing, and packaging, are limited. The closest residential properties are those located along the western fence line of JPL. The nearest off-facility buildings are the Flintridge Riding Club and Fire Camp #2, both located approximately 100 yards from the southern border of JPL. The total number of buildings within 2 miles of JPL is about 2,500, primarily residential and community (e.g., schools, day-care centers, churches). Land use at JPL is not expected to change significantly in the foreseeable future.

6.2 Surface Water and Groundwater Uses

There are no permanent surface water bodies within the boundaries of JPL. The Arroyo Seco Creek intermittently flows through the Arroyo Seco wash to the east of JPL. The entire JPL site drains, via storm drains and surface runoff, into the Arroyo Seco. In addition, stormwater runoff from parts of La Cañada Flintridge mingles with that of JPL prior to discharge to the Arroyo. Within the Arroyo Seco, a series of surface impoundments are used as surface water collection and spreading basins for groundwater recharge.

Groundwater beneath the Arroyo Seco is a current source of drinking water. The Raymond Basin Watershed, Monk Hill Subbasin, where JPL is located, provides an important source of potable water for many communities in the area around JPL. These communities are expected to grow at a modest rate for the foreseeable future and the use of groundwater as drinking water is expected to continue.

7.0: SUMMARY OF SITE RISKS (OPERABLE UNIT 2)

This section of the ROD summarizes the results of the baseline HHRA and the ERA for OU-2. The risk assessment process identifies potential exposure pathways and allows evaluation of the risks to humans and the ecosystem, if no further action were taken at the site.

7.1 Summary of Human Health Risk Assessment

The baseline HHRA in the OU-2 RI (FWEC, 1999a) evaluated the potential risks to the hypothetical on-facility resident, the commercial worker, and the construction worker potentially exposed to chemicals in on-facility soil at JPL. The exposure pathways considered in the HHRA included ingestion, dermal contact, and inhalation. The potential human receptor at greatest risk was the hypothetical on-facility resident. Although NASA has no intent to use JPL for residential purposes in the foreseeable future, the HHRA included a hypothetical residential use scenario (i.e., someone living on the JPL property) to provide the most conservative and protective results.

For carcinogenic compounds, the exposure risk is expressed as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the carcinogen. These risks are expressed in scientific notation (e.g., an excess lifetime cancer risk of 1.0×10^{-6} indicates that an individual experiencing the conservative maximum exposure estimate has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure). According to the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 1.0×10^{-6} is defined as the point of departure (i.e., the target level of risk) and the NCP-defined generally acceptable range is 1.0×10^{-6} to 1.0×10^{-4} (EPA, 1989).

For noncarcinogenic compounds, risks are evaluated by comparing an exposure level over a specified time period (e.g., lifetime) with a reference dose or level that is not expected to cause any harmful effects. The ratio of the chronic daily intake to the reference dose is called a hazard quotient (HQ). The sum of all of the hazard quotients for each chemical compound is referred to as the hazard index (HI). An HI less than 1.0 indicates that toxic, noncarcinogenic effects from all chemical constituents and exposure routes are unlikely (EPA, 1989).

All chemicals detected in soil samples collected in the upper 15 ft of the vadose zone and in soil vapor samples collected in the upper 30 ft of the vadose zone were evaluated in the HHRA. Screening levels were derived based upon a conservative residential-use scenario following the guidelines outlined by the State of California (DTSC, 1994) and the EPA (1989, 1991, 1998). The screening levels were based on an acceptable target risk of 1×10^{-6} for carcinogens and a hazard quotient of 1.0 for noncarcinogens. Based on this evaluation, NASA identified four chemicals that exceeded screening levels, including Arochlor-1254, Arochlor-1260, arsenic, and hexavalent chromium.

The maximum detected values of these four chemicals were used to calculate chemical intakes and to evaluate the site-specific lifetime cancer risks and noncancer risks. Table 7-1 provides a summary of the estimated carcinogenic risks associated with these chemicals for residential receptors at Discharge Point No. 2, Discharge Point No. 3, Discharge Point No. 4, Waste Pit No. 1/Discharge Point No. 1., and Waste Pit No. 4. Table 7-2 provides a summary of the estimated non-carcinogenic risks associated with these chemicals for residential receptors at the same locations. Based on the results of the HHRA as detailed in the OU-2 RI report (FWEC, 1999a), NASA, the EPA, and the state agencies concurred that there is negligible risk to potential receptors, both on-facility and off-facility, due to exposure to on-facility soils at JPL.

Table 7-1. Risk Characterization Summary – Carcinogens

Exposure Point	Chemical	Ingestion	Inhalation	Dermal	Exposure Routes Total
Discharge Point No. 2	Chromium (VI)	1.8×10^{-7}	5.8×10^{-7}	0	7.7×10^{-7}
Discharge Point No. 3	Arsenic	1.1×10^{-5}	2.2×10^{-7}	3.8×10^{-6}	1.5×10^{-5}
Discharge Point No. 4	Arsenic	1.1×10^{-5}	2.3×10^{-7}	4.0×10^{-6}	1.5×10^{-5}
Waste Pit No. 1/ Discharge Point No. 1	Arochlor-1254	6.3×10^{-7}	1.6×10^{-9}	1.1×10^{-6}	1.8×10^{-6}
	Arochlor-1260	8.5×10^{-7}	2.2×10^{-9}	1.5×10^{-6}	2.4×10^{-6}
	Arsenic	7.0×10^{-6}	1.5×10^{-7}	1.3×10^{-5}	2.0×10^{-5}
	Chromium (VI)	1.8×10^{-7}	1.7×10^{-6}	0.0	1.9×10^{-6}
Waste Pit 4	Arsenic	1.3×10^{-5}	2.7×10^{-7}	4.7×10^{-6}	1.8×10^{-5}

Note: Receptor population is a hypothetical on-site resident (i.e., someone living on the JPL property)

Table 7-2. Risk Characterization Summary – Noncarcinogens

Exposure Point	Chemical	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Discharge Point No. 2	Chromium (VI)	None	0.0012	0.0039	0.0	0.0051
Discharge Point No. 3	Arsenic	Skin	0.19	NA	0.058	0.25
Discharge Point No. 4	Arsenic	Skin	0.2	NA	0.06	0.26
Waste Pit No. 1/ Discharge Point No. 1	Arochlor-1254	Eyes	0.13	0.00032	0.19	0.32
	Arochlor-1260	NA	NA	NA	NA	NA
	Arsenic	Skin	0.13	NA	0.19	0.32
	Chromium (VI)	None	0.0036	0.012	0.0	0.0156
Waste Pit 4	Arsenic	Skin	0.24	NA	0.072	0.31

Note: Receptor population is a hypothetical on-site resident (i.e., someone living on the JPL property)

7.2 Summary of Ecological Risk Assessment

The screening-level ERA in the OU-2 RI report (FWEC, 1999a) evaluated the potential risks to ecological receptors exposed to chemicals in on-facility soil at JPL. Chemicals of potential concern for the ERA included chromium, lead, mercury, molybdenum, vanadium, and zinc. The ecological risks associated with exposure to these chemicals were quantitatively evaluated for the deer mouse and the American kestrel through the calculation of HQs (FWEC, 1999a).

The HQ for lead from one soil sample location exceeded 1 for both the deer mouse and the American kestrel. However, uncertainty regarding the form of lead in the sample, as well as the conservative exposure parameters used in the evaluation, likely overestimated the risk from the sample. Animals with large home ranges, such as the American kestrel, are not likely to be at risk because they would potentially obtain only a small fraction of their diet from this location. JPL is a developed, non-wilderness area, so it is not likely to provide high-quality habitat for these species. In addition, lead concentrations found at JPL are within the range of background values for California and western U.S. soils. Thus, potential ecological risks from lead are likely to be lower than indicated by the estimated value. All other constituents had HQs less than 1 for the American kestrel and less than 10 for the deer mouse. Constituents, which yielded an HQ above 1 for the deer mouse, included chromium, molybdenum, and zinc. Since JPL is a developed industrial complex and does not provide quality habitat, these HQs represent an acceptable risk.

7.3 Basis for Action

Although results of the HHRA and the ERA showed that chemicals in on-facility soil at JPL pose no significant direct risks to humans or the ecosystem, the results of analyses performed during the OU-2 RI (FWEC, 1999a) indicated that chemicals in vadose zone soil at JPL have the potential to migrate to groundwater. The remedial strategy is to use SVE technology to remove VOCs from the vadose zone in order to reduce their migration to groundwater and to protect an existing drinking water source.

8.0: REMEDIAL ACTION OBJECTIVES

In order to identify and screen alternatives for the remediation of OU-2, a remedial action objective (RAO) has been established to prevent unacceptable levels of chemicals in the vadose zone from migrating into groundwater. Development of RAOs to protect human health and ecological receptors from exposure to soil are not needed because the HHRA determined that direct exposure to site soils does not pose unacceptable risks to humans, and the ERA concluded that no significant ecological risks from chemicals in soil exist (FWEC, 1999a). However, because groundwater is a resource that must be protected, an RAO to protect groundwater is required.

The development of an RAO includes consideration of applicable or relevant and appropriate requirements (ARARs) in accordance with CERCLA, as amended by SARA and NCP. The RAO for OU-2 is to prevent, to the extent practicable, further migration of VOCs at potential levels of concern from the vadose zone to groundwater to protect an existing drinking water source.

9.0: DESCRIPTION OF ALTERNATIVES

Two remedial alternatives were evaluated for OU-2, on-facility vadose zone soil at JPL to achieve the RAO. Alternative 1 is the “no further action” (NFA) alternative and Alternative 2 is SVE. Both alternatives include a soil vapor monitoring program, currently in place, to track concentrations and the extent of chemicals in soil vapor over time.

9.1 Alternative 1: No Further Action

9.1.1 Description of Remedy Components

The NFA alternative includes no active treatment or containment activities to remediate chemicals in on-facility soil at JPL, and no institutional controls to protect the public or the environment from exposure to chemicals in soil. However, it does include a soil vapor monitoring program, currently in place at JPL. As part of the NFA alternative, the results of the monitoring program are then used to track concentrations and the extent of chemicals in soil vapor beneath JPL over time. The concentrations and extent of chemicals in soil vapor may decrease gradually over time due to chemical or physical transformation, sorption, and/or dilution.

9.1.2 Common Elements and Distinguishing Features

Because soil vapor monitoring is the only active component of the NFA alternative, this alternative is not likely to meet chemical-specific ARARs for OU-2. The NFA alternative is not likely to be effective over the long term or to meet the RAO for OU-2 in a reasonable time frame because chemicals in vadose zone soil are not removed and can continue to migrate into the groundwater. For a discussion of ARARs for OU-2, see Section 13.2 of this report.
Operation and maintenance (O&M) costs for the soil vapor monitoring program at OU-2 are estimated at approximately $1,477,000 (present-worth value), based on 45 sampling events. More details on estimated costs are provided in the OU-2 FS (FWEC, 2000).

9.1.3 Expected Outcomes

The NFA alternative is not a treatment or containment technology and is not expected to reduce the toxicity, mobility, or volume of contaminants at OU-2. Under the NFA alternative, no remediation of OU-2 is planned except that which occurs naturally due to chemical/biological degradation, dispersion, advection, and sorption. The NFA alternative is not expected to prevent further migration of VOCs to groundwater, and thus, is not expected to meet the RAO for OU-2.

9.2 Alternative 2: Soil Vapor Extraction

9.2.1 Description of Remedy Components

Alternative 2 includes the soil vapor monitoring program described for the NFA alternative, plus SVE to remediate vadose zone soil. During SVE, VOCs are removed from the subsurface in vapor form by applying a vacuum to an underground well. The extracted soil vapor is then treated to remove VOCs in order to meet air permit discharge requirements and prevent their release to the atmosphere.

The proposed SVE system for OU-2 consists of a combination of up to five vapor extraction wells and vapor treatment systems. New wells will be installed and constructed in a manner similar to the existing SVE pilot well (VE-01) at JPL. SVE systems will be operated until the criteria for discontinuing their operation have been met. Activities associated with the monitoring program will be discontinued once remedial performance objectives have been achieved.

9.2.2 Common Elements and Distinguishing Features

SVE is a treatment technology that can meet chemical-specific ARARs because chemicals are removed from the vadose zone to reduce their migration to groundwater. In addition, chemical-specific ARARs pertaining to discharge of air are addressed by the vapor treatment system. Location-specific ARARs will also be considered during the remedial design phase. For more detail on ARARs, see Section 13.2 of this report.

SVE is a presumptive remedy commonly used to clean up sites similar to OU-2, where VOCs are present in vadose zone soil (EPA, 1993). Further, SVE was shown to be effective at OU-2 based on the pilot study results, during which it was documented that over 200 lbs of VOCs were removed. Finally, the SVE alternative is effective over the long term, because VOCs in vadose zone soil are permanently removed.

Maximum capital costs for SVE are estimated at approximately $874,000 (assuming five extraction wells and five vapor treatment systems). O&M costs are estimated at approximately $2,861,000 (present-worth value), which includes soil vapor monitoring. The SVE system configuration, sampling frequencies, and duration used are for cost-estimating and comparison purposes only. A summary of estimated costs is presented in Section 11.3 and more detail is provided in the OU-2 FS (FWEC, 2000).

It is estimated that the implementation time frame for design and construction of the full-scale SVE system will be less than 12 months following certification of the ROD. The exact period of performance for the SVE system cannot be accurately determined at this time. Based on past project experience and literature case studies, a typical period of operation for an SVE system is l2 to 18 months.

9.2.3 Expected Outcomes

The SVE alternative is an EPA-designated presumptive remedy (EPA, 1993) that is expected to permanently reduce the volume of VOCs at OU-2, and to reduce VOC migration to groundwater. Thus, the SVE alternative is expected to meet the RAO for OU-2 and to improve the effectiveness and efficiency of the selected remedy for OU-1 and OU-3 by removing VOC mass that could eventually migrate to groundwater. In addition, implementation of SVE is not expected to restrict normal activities or future land use at JPL.

10.0: SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

NASA evaluated the remedial alternatives for OU-2 in accordance with the nine criteria defined in NCP (40 Code of Federal Regulations [CFR] Part 300). The nine evaluation criteria are as follows:

- Protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume of contaminants
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance.

These nine evaluation criteria can be categorized into three groups: threshold criteria, primary balancing criteria, and modifying criteria. All threshold criteria must be satisfied for a remedial alternative to be eligible for selection. The threshold criteria are protection of human health and the environment and compliance with ARARs. The primary balancing criteria are used to weigh major tradeoffs among alternatives. The primary balancing criteria are long-term effectiveness and permanence, reduction of toxicity, mobility, or volume of contaminants through treatment, short-term effectiveness, implementability, and cost. The modifying criteria, state and community acceptance, are usually addressed after public comment is received on the Proposed Plan. At that time, public comments are reviewed with state regulatory agencies to determine if the preferred alternative remains the most appropriate remedial action.

10.1 Comparison of Remedial Alternatives Using Evaluation Criteria

This section uses the nine evaluation criteria to compare and evaluate the remedial action alternatives for OU-2. Table 10-1 summarizes the screening of the two alternatives for OU-2: Alternative 1, NFA and Alternative 2, SVE.

10.2 Protection of Human Health and the Environment

The HHRA in the OU-2 RI (FWEC, 1999a) determined that direct exposure to soil at JPL does not pose unacceptable risks to humans, and the ERA in the OU-2 RI concluded that no significant ecological risks exist. Thus, both Alternative 1, NFA, and Alternative 2, SVE, are protective of human health in terms of exposure to chemicals through direct contact with near-surface soils. However, if not removed, VOCs in the vadose zone may continue to migrate to groundwater. Because of this possibility, Alternative 1 is not protective of groundwater. Under Alternative 2, the amount of VOCs that will migrate to groundwater is reduced.

Table 10-1. Comparison Summary of Remedial Alternatives for OU-2

Criteria	Alternative 1	Alternative 2
Description	• No Further Action • Soil Vapor Monitoring	• SVE • Off-Gas Treatment • Soil Vapor Monitoring
Overall Protection	• Not protective of environment	• Short- and long-term protection of environment by reducing VOC concentrations and migration to groundwater
Compliance with ARARs	• Does not comply with ARARs since groundwater is not protected	• Complies with ARARs • Treats vadose zone to levels that will minimize VOC migration and be protective of groundwater • Because waste is removed in place through limited construction and no excavation, no impacts to surface water quality are expected. • Emission controls needed to ensure compliance with air quality standards
Long-Term Effectiveness and Permanence	• Not effective in long-term • VOCs remain in vadose zone and could migrate to groundwater	• Well-established technique for removing VOCs from soil • VOCs permanently removed from vadose zone • Requires some treatment or disposal of residuals (e.g., spent carbon stream)
Reduction of Toxicity Mobility, or Volume	• No reduction in mobility or volume of VOCs	• Significantly reduces mobility and volume of VOCs through treatment
Short-Term Effectiveness	• No risk to workers, community, or environment	• Does not present substantive risks to on-facility workers or community in short term • Potential air emissions are easily controlled through GAC or other technologies. • Generally involves relatively short time frame to achieve cleanup levels
Implementability	• Easily implemented	• Technology is readily available from many sources • Effective for treating waste under buildings. Can be performed on active facilities. • Installing and operating extraction wells requires fewer engineering controls than other technologies (i.e., excavation and incineration).
Cost	• Approximate cost: $1,477,000	• Approximate cost: $3,735,000
Conclusion	• Does not meet first two threshold criteria	• Preferred Alternative

10.3 Compliance with Applicable or Relevant and Appropriate Requirements

Appendix F of this document contains an evaluation of ARARs that may apply to OU-2. They include the Safe Drinking Water Act; various resolutions, guidance documents, and plans set forth by the RWQCB; the Federal Facilities Compliance Act; Executive Order 11988 (Protection of Floodplains); the Archaeological Resources Protection Act; the National Historic Preservation Act; the Clean Air Act; various regulations set forth by the South Coast Air Quality Management District; and the Resource Conservation and Recovery Act.

Alternative 1, NFA, does not meet chemical specific ARARs since groundwater at JPL is not protected. Alternative 2, SVE, meets all identified ARARs and reduces the migration of VOCs to the groundwater.

10.4 Long-Term Effectiveness and Permanence

Alternative 1, NFA, is not effective over the long term because, under this alternative, chemicals in the vadose zone can continue to migrate into groundwater.

Alternative 2, SVE, is effective for the long term. The SVE process permanently removes VOCs from vadose zone soil through a vacuum applied to underground wells. The vapors are then treated to remove VOCs and prevent their release to the atmosphere. Because chemicals are permanently removed from the soil, existing and future risks to groundwater are reduced. Thus, long-term effectiveness is achieved.

10.5 Reduction of Toxicity, Mobility, or Volume of Contaminants

Alternative 1, NFA, is not a treatment technology and does nothing to reduce the toxicity, mobility, or volume of chemicals in soil at OU-2. Alternative 2, SVE, permanently removes VOCs from the vadose zone reducing both the volume and mobility of chemicals in soil at JPL. The results of the pilot study, during which more than 200 pounds of VOCs were removed from a single pilot extraction well, show that VOC mass removal can be significant.

10.6 Short-Term Effectiveness

Alternative 1, NFA, entails no remedial action. Because soil vapor sampling does not require construction or installation of equipment on site, potential short-term effects to workers, the public, and the environment are minimal.

Similarly, Alternative 2, SVE, presents minimal risks to workers, the public, and the environment. System construction is localized and procedures would be followed that monitor and prevent exposure to VOCs. SVE systems are designed so that extraction wells and associated piping are under vacuum. The VOCs in the extracted air are removed by an aboveground treatment system in accordance with federal, state, and local ARARs.

10.7 Implementability

Alternative 1, NFA, is easily implemented. The equipment and methods used for soil vapor sampling and analysis are commercially available.

Alternative 2, SVE, is a common remediation process for treatment of VOCs in soil, and equipment is readily available from commercial sources. Further, installation and operation of SVE systems require relatively few engineering controls compared to other remediation technologies.

10.8 Costs

A summary of the present-worth costs associated with the remedial alternatives for OU-2 is presented in Table 10-2. The OU-2 FS (FWEC, 2000) contains a detailed breakdown of these costs. The only costs associated with Alternative 1, NFA, are O&M costs for the soil vapor monitoring program. For cost-estimating purposes, conservative assumptions were made regarding the monitoring program consisting of quarterly sampling for the first five years of the remedial program, followed by annual sampling for 25 more years.

Costs associated with Alternative 2, SVE, include installation and operation of five extraction wells and five off-gas extraction and treatment systems, as well as soil vapor monitoring. The new extraction wells are assumed to be similar in construction to the existing pilot SVE well (VE-01). O&M costs for Alternative 2 include operation and maintenance of the SVE systems and the soil vapor monitoring program. Soil vapor monitoring costs are assumed to be the same as for Alternative 1.

Table 10-2. Comparison of Cost Estimates for Alternatives 1 and 2

Description	Capital Costs[a]	O&M Costs[a,b]	Total Cost[a,b,c]
Alternative 1: NFA			
Soil Vapor Monitoring	-	$1,477,000	$1,477,000
Total Cost	**-**	**$1,477,000**	**$1,477,000**
Alternative 2: SVE			
Soil Vapor Monitoring	-	$1,477,000	$1,477,000
Soil Vapor Extraction	$ 874,000	$1,384,000	$2,258,000
Total Cost	**$874,000**	**$2,861,000**	**$3,735,000**

(a) Costs are estimated to the nearest $1,000.
(b) O&M and total costs are estimated at present-worth value. Estimates are within a –30% to +50% range of accuracy.
(c) Total cost includes capital costs and annual O&M costs incurred over the estimated duration.

10.9 State Acceptance

The state acceptance criterion requires that NASA, as the responsible party, address the state's comments and concerns for each proposed remediation alternative. Comment responses have been accepted by the state. All state agencies have agreed to the proposed remedial Alternatives 1 and 2, and to the selected remedy, Alternative 2. This ROD/Remedial Action Plan (RAP) documents state acceptance of Alternative 2. The DTSC and RWQCB concur with the recommendations of this ROD.

10.10 Community Acceptance

NASA carefully evaluated all public comments taking into consideration information provided by the public and responded to all questions. Part III of this ROD documents the comments that NASA received from the public about OU-2 and provides NASA's responses to those comments. Although NASA received a number of comments and questions during the public comment period for the Proposed Plan, none of the public stakeholders objected to implementation of the selected remedy.

11.0: THE SELECTED REMEDY

As required by CERCLA and NCP, remedial alternatives were identified in the FS and screened based on effectiveness, implementability, and cost. These alternatives were then subject to detailed analysis using the nine criteria described in Section 10.0 of this ROD. Based on the comparative analysis of the remedial alternatives, the selected remedy for addressing OU-2 is Alternative 2, SVE, which also includes soil vapor monitoring. NASA, EPA, DTSC, and RWQCB agree with the selection of this alternative for remediation at OU-2.

11.1 Rationale for the Selected Remedy

Based on the evaluation of threshold and primary balancing criteria in Section 10.0, Alternative 2, SVE, is the most effective remedial alternative for vadose zone soil at JPL. Because of the potential for continued migration of VOCs to groundwater, Alternative 1, NFA, is not protective, and the RAO for OU-2 cannot be met under this alternative. Alternative 2, SVE, will remove VOCs from the vadose zone, and thus reduce the migration of VOCs to groundwater. The EPA identified SVE as a presumptive remedy for sites with VOCs in soil (EPA, 1993) and NASA has determined that it is appropriate to apply the presumptive remedy at OU-2 based on the results of a pilot test conducted during the FS (FWEC, 2000).

11.2 Description of the Selected Remedy

Under the selected remedy, VOCs in the vadose zone are treated using SVE. The SVE system for OU-2 will consist of up to five vapor extraction wells and vapor treatment systems. New wells will be installed and constructed in a manner similar to the existing SVE pilot well (VE-01), as described in the OU-2 FS (FWEC, 2000). When operation of the SVE system is no longer necessary and/or cost-effective to mitigate VOC migration to groundwater at levels of potential concern, the system will be shut down and dismantled.

The soil vapor extracted from the subsurface will contain VOCs at levels that may require treatment before being discharged to the atmosphere. Several different options for vapor treatment of chlorinated VOCs are available, including granular activated carbon (GAC) adsorption, VOC-adsorbing resins, and catalytic oxidation. Currently, the preferred choice for off-gas treatment is GAC, which is a technology proven to be effective for VOC treatment. Once the GAC becomes saturated with VOCs, it will be removed and replaced with fresh GAC. The spent GAC will then be transported (in compliance with Department of Transportation [DOT] requirements) off-site to a permitted facility to be regenerated or disposed of. The preferred method of VOC vapor treatment may be modified based on the concentrations of VOCs in extracted soil vapor.

The current SCAQMD air permit requires collection of daily SVE system influent and effluent (stack) vapor samples, which are analyzed for VOCs using a hand-held meter. In addition, every two weeks SVE system influent and effluent vapor samples are collected and analyzed by a laboratory for VOCs using EPA Method TO-14.

The selected remedy also includes an ongoing soil vapor monitoring program. This program will be used to evaluate SVE system effectiveness and remedial progress. The soil vapor monitoring program will be terminated upon achieving the RAO.

11.3 Estimated Remedy Costs

Table 11-1 presents the estimated capital costs for the full-scale SVE system at OU-2. The term capital cost refers to the funds required to cover the initial nonrecurring costs associated with purchasing and installing the technology to the point where it is ready for its intended use. The capital cost estimate for the SVE system at JPL OU-2 is based on the installation of a maximum of five extraction wells and five vapor treatment systems. Costs associated with the installation of the SVE wells include drilling expenses, waste disposal, well materials, and other miscellaneous expenses. Costs associated with the installation of the vapor treatment system(s) include the purchase of equipment such as blowers, carbon vessels, and piping. The design and construction management costs are also included as part of the capital cost.

The O&M costs of a technology are the recurring or periodic costs incurred during the operating life of the system. SVE O&M costs include labor, equipment rental, carbon replacement costs, electricity, and other expenses. Table 11-2 presents the annual O&M costs for SVE at OU-2.

In addition to the SVE O&M costs, soil vapor monitoring and Five-Year Reviews costs were considered as part of the remedy operation costs. Soil vapor monitoring costs were estimated to be $51,000 per sampling event and Five-Year Review costs were estimated to be $11,000 per review.

Table 11-1. Estimate of Capital Costs for SVE

Well Installation (5 Wells)	Quantity	Unit	Unit Cost	Total Cost
Driller	1,000	Linear feet	$125	$125,000
Mobilization/Demobilization	2	Each	$4,000	$8,000
Equipment Rental	25	Days	$500	$12,500
Labor	60	Person-days	$1,000	$60,000
Soil Bins/Water Tanks	1	Lump Sum	$10,000	$10,000
Soil Disposal	39	Tons	$100	$3,900
Miscellaneous	5	Each	$5,000	$25,000
Vapor Extraction and Treatment Equipment	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Blower Package	5	Each	$30,000	$150,000
Carbon Vessels	20	Each	$7,000	$140,000
Piping Manifolds	5	Each	$10,000	$50,000
Fence	5	Each	$3,000	$15,000
Miscellaneous	5	Each	$5,000	$25,000
Subtotal Capital Costs				**$624,400**
Design/Construction Management	1	Lump Sum	$93,700	$93,700
Contingency (25%)	1	Lump Sum	$156,100	$156,100
Total Capital Costs for SVE				**$874,200**

Table 11-2. Estimate of Annual Operation and Maintenance Costs for SVE

Field Program	Quantity	Unit	Unit Cost	Total Cost
Labor	60	Person-days	$800	$48,000
Equipment Rental	30	Days	$200	$6,000
Laboratory	120	Samples	$160	$19,000
Carbon	40	Tons	$3,000	$120,000
Electricity	841	MW hour	$100	$84,100
Miscellaneous	12	Month	$1,000	$12,000
Field Program Subtotal				**$289,300**
Reporting	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Data Analysis	300	Hours	$100	$30,000
Reporting	100	Hours	$100	$10,000
Reporting Subtotal				**$40,000**
Total SVE O&M Costs Per Year				**$329,300**

Note (a) Cost estimate assumes that one Five Year Review is completed every year for 30 years.

The total present worth of the SVE remediation project is estimated to be $3,735,300 based on the capital costs, the annual SVE O&M costs, the soil vapor monitoring costs, and the five-year review costs incurred over the life of the project. The term “present worth” represents the amount of money or principal needed today to cover all of the costs over the lifetime of the remediation project given a certain interest rate. This present-worth cost estimate was based on the following simplifying assumptions:

- The implementation time for the selected remedy is 30 years.
- The remediation program is reviewed every five years.
- 45 soil vapor monitoring events.
- SVE continues for five years.

The SVE system configuration, sampling frequencies, and project duration listed in the proceeding sections are conservative, for cost-estimating purposes only, and may vary during remedy implementation. In addition, the number of five-year reviews described above is for cost-estimating purposes only and may vary during project implementation.

11.4 Expected Outcomes of the Selected Remedy

The selected remedy for OU-2 considers the soil-to-groundwater migration pathway and provides for cleanup of the vadose zone to be protective of beneficial uses of groundwater. JPL is located within the Raymond Basin Watershed, which is a current source of drinking water.

It is anticipated that the selected remedy will help to reduce groundwater treatment costs and help to restore aquifer water quality. The remedial approach for the implementation of SVE at OU-2 is summarized in Figure 11-1. The SVE system will be operated and optimized until performance objectives have been achieved. The performance of the SVE system will be evaluated on a continuing basis and the information regarding the amount of VOCs removed will be reported to the regulatory agencies as needed to effectively evaluate system performance objectives. The performance objectives include the following:

- Reduction of overall VOC concentrations at the vapor monitoring points and extraction wells compared to baseline levels. This includes fate and transport modeling to evaluate leaching to groundwater (using RWQCB guidance [RWQCB, 1996] and/or VLEACH™) and groundwater mixing.

- Asymptotic mass removal achieved after temporary shutdown periods and appropriate optimization of the SVE system. Asymptotic conditions will have been reached at a given SVE well when the upper limb of the cumulative mass removal curve is substantially linear and the slope of the curve approaches zero. In addition, rebound of chemical concentrations will be evaluated during the temporary shutdown periods. A general asymptotic decreasing trend in rebound of chemical concentrations in the soil vapor monitoring points will be demonstrated. Time series plots of VOC concentrations at each soil gas monitoring point will be prepared to assist in evaluation of rebound.

- Operate only as long as cost-effective. The SVE system will no longer be cost-effective when operating costs per unit of VOC mass removed from the vadose zone indicate that the additional cost of continuing to operate the SVE system is not warranted and/or when shutdown of the SVE system is not anticipated to significantly increase the cost of the groundwater remedy or significantly prolong the time to achieve groundwater cleanup.

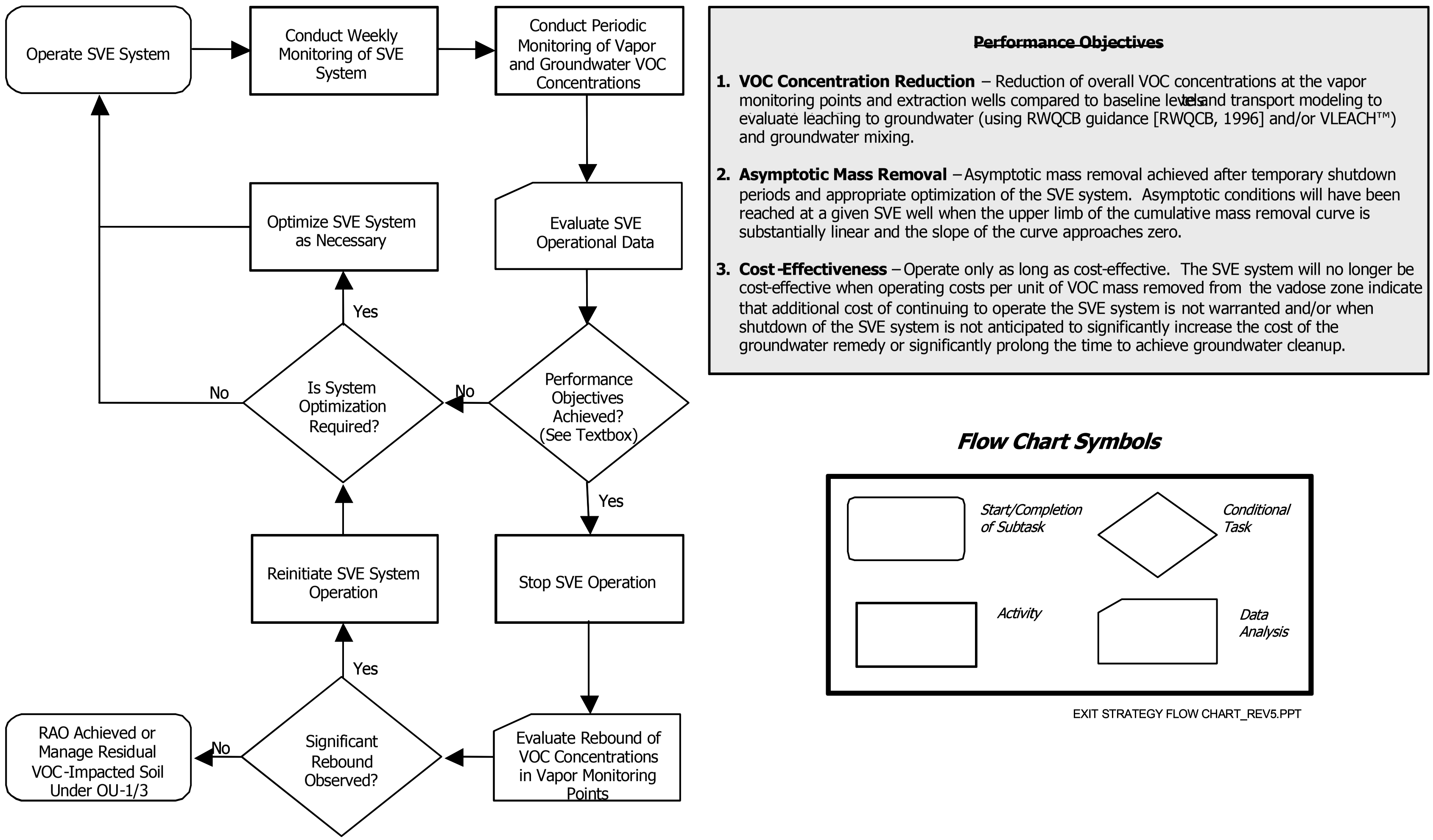

Figure 11-1. Remedial Approach Flowchart

The existing vapor monitoring network will be evaluated during the remedial design phase to determine if sufficient coverage is available to monitor changes in the lateral and vertical distribution of VOCs and the effectiveness of cleanup. Additional soil vapor monitoring points will be installed as necessary to monitor effectiveness of the remedy. In addition, the existing groundwater monitoring network will be used as part of the evaluation of SVE effectiveness. After the performance objectives have been achieved, the SVE system will be idled and soil vapor monitoring will continue to evaluate rebound. If significant rebound occurs, the SVE system will be reinitiated; otherwise the SVE system will be permanently shut down and dismantled. Following shutdown, any residual VOCs remaining in the vadose zone will be managed under OU-1/OU-3. NASA will evaluate chemical fate and transport during the remedial design and periodically during system operation. When performance objectives have been achieved, NASA will request shutdown of the SVE system. The complete modeling results and other data used to evaluate compliance with the performance objectives will be provided to the regulatory agencies for review and approval prior to initiating actions to terminate operation of the SVE system. NASA will shut-down the SVE system once approval has been granted by the EPA, DTSC and RWQCB.

Minimal environmental impacts are expected from SVE implementation. SVE will have no adverse impacts on threatened or endangered species, cultural resources, floodplains, or wetlands. NASA expects no adverse human health impacts from this CERCLA action to occur in any off-facility community, including minority and low-income communities. With SVE implementation, increases in JPL traffic will be minimal and consist of transportation of SVE equipment and supplies to and from the JPL site, resulting in insignificant transportation impacts. There will be no measurable impact on the local economy as a result of SVE implementation, and thus, no socioeconomic impacts are anticipated. Also, there will be no irreversible and irretrievable commitment of resources and the cost of remediation is justified to protect the existing source of drinking water.

Additional information regarding the anticipated socioeconomic, transportation, natural resources, and environmental justice impacts associated with the implementation of SVE are discussed in the NEPA Values Assessment, which is provided in Appendix E.

12.0: REMEDIAL ACTION PLAN REQUIREMENTS

The DTSC RAP requirements are presented in Table 12-1. The DTSC has concurred that the referenced sections of the OU-2 RI report (FWEC, 1999a) and the OU-2 FS (FWEC, 2000) satisfy the RAP requirements. Any revised or additional RAP requirements will be provided and administered by the DTSC. A copy of the California Health and Safety Code (HSC), Section 25356.1, RAP requirements, is included in the ROD as Appendix A.

Table 12-1. DTSC RAP Requirements

RAP Requirement	Reference Location
Health and safety risks posed by the conditions at OU-2. When considering these risks, DTSC or the RWQCB shall consider scientific data and reports that may have a relationship to OU-2.	OU-2 RI report, Section 6.0, Appendices H and I (FWEC, 1999a); OU-1/OU-3 RI report (FWEC, 1999b)
The effect of VOC levels on present, future, and probable beneficial uses of affected resources.	OU-2 RI report, Section 6.0, Appendices H and I (FWEC, 1999a); OU-1/OU-3 RI (FWEC, 1999b)
The effect of alternative remedial action measures on the reasonable availability of groundwater resources for present, future, and probable beneficial uses.	OU-2 FS, Sections 3.0 and 4.0 (FWEC, 2000); NEPA Values Assessment for Operable Unit 2, Sections E.3.0 and E.4.0 (Appendix E)
Specific characteristics of OU-2, including the potential for off-facility migration of VOCs, the surface and subsurface soil, the hydrogeologic conditions, and preexisting background levels of contamination.	OU-2 RI report, Sections 2.0 and 4.0, Appendices A, B, C, D, E, F, and G (FWEC, 1999a); OU-1/OU-3 RI report (FWEC, 1999b)
Cost-effectiveness of alternative remedial action measures.	OU-2 FS, Sections 4.0 and 5.0 (FWEC, 2000)
The potential environmental impacts of alternative remedial action measures, including treatment of VOCs to remove or reduce their volume, toxicity, or mobility prior to disposal.	OU-2 FS, Sections 4.0 and 5.0 (FWEC, 2000); NEPA Values Assessment, Sections E.4.0 and E.5.0 (Appendix E)

13.0: STATUTORY DETERMINATIONS

NASA must undertake remedial actions at this CERCLA site to achieve protection of human health and the environment. In addition, the selected remedy for this site must meet applicable or relevant and appropriate environmental standards as established under federal and state environmental laws, unless a statutory waiver is justified. The selected remedy must also be cost-effective and use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. Finally, the remedy should also employ treatment to permanently and significantly reduce the volume, toxicity, or mobility of chemicals in the vadose zone. This section provides a brief description of how the selected remedy, SVE, satisfies the statutory requirements of CERCLA.

13.1 Protection of Human Health and the Environment

Although results of the HHRA and the ERA showed that chemicals in on-facility soil at JPL pose no significant direct risks to humans or the ecosystem, the results of analyses performed during the OU-2 RI (FWEC, 1999a) showed that chemicals in vadose zone soil at JPL may have the potential to continue to migrate to groundwater. The remedial strategy is to use SVE to remove

VOCs from the vadose zone in order to reduce the migration of these chemicals to groundwater and to protect an existing drinking water source.

Air emissions associated with the implementation of SVE will be limited to possible dust generation during well installation and discharge of treated vapors extracted from the subsurface. The dust generation during well installation will be minimal and occur over a short duration. Therefore, these emissions are expected to have negligible impacts on local air quality. The VOCs in the extracted vapor will be removed by an aboveground treatment system in accordance with state and local regulations. These regulations ensure protection of human health and the environment.

SVE system installation and operation will also result in negligible impacts and minimal waste generation because the system is operated in situ. Solid waste, in the form of spent carbon from the vapor treatment system, will be transported and treated off site. Thus, SVE will have negligible impacts during operation and will be protective of human health and the environment.

Because the SVE process permanently removes VOCs from the vadose zone, the potential for further groundwater impact is reduced. Thus, long-term protection is provided to human health and the environment.

13.2 Compliance with Applicable or Relevant and Appropriate Requirements

The selected remedy, SVE, complies with federal and state ARARs. ARARs were identified on a site-specific basis from information about the constituents of interest, the specific actions being considered, and the features of the JPL site. The federal and state chemical-specific, location-specific, and action-specific ARARs for OU-2 are discussed in Appendix F.

13.3 Cost-Effectiveness

Cost-effectiveness is determined by comparing the cost of all alternatives being considered with their overall effectiveness to determine whether costs are proportional to the effectiveness achieved. The overall effectiveness of a remedial alternative is determined by evaluating (1) long-term effectiveness and permanence, (2) reduction in toxicity, mobility, or volume through treatment, and (3) short-term effectiveness. Table 13-1 presents a comparison of costs and effectiveness of Alternative 1, NFA, and Alternative 2, SVE, for OU-2.

Alternative 1, NFA, is not effective over the long term because, under this alternative, VOCs in the vadose zone can continue to migrate into groundwater. Alternative 2, SVE, is effective over the long term because the SVE process permanently removes VOCs from vadose zone soil and existing and future risks to groundwater are reduced. After remediation is complete, residual VOCs are not expected to further impact groundwater.

Table 13-1. Comparison of Costs and Effectiveness of Alternatives for OU-2

Alternative	Present-Worth Cost	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness
Alternative 1, NFA	$1,477,000	• Not effective over the long term • VOCs in vadose zone soil can continue to migrate into groundwater	• Not a treatment technology • Does not reduce toxicity, mobility, or volume of VOCs in vadose zone soil	• No short-term effects on workers, public, or the environment
Alternative 2, SVE	$3,735,000	• Effective over the long term • VOCs permanently removed from vadose zone soil	• Presumptive remedy • Permanently removes VOCs from vadose zone soil	• Insignificant short-term effects on workers, the public, and the environment

Alternative 1, NFA, is not a treatment technology and does not reduce the toxicity, mobility, or volume of VOCs in vadose zone soil at OU-2. Alternative 2, SVE, is an EPA presumptive remedy that permanently and irreversibly removes VOCs from soil (EPA, 1993). Thus, Alternative 2 reduces the volume and mobility of VOCs in vadose zone soil at OU-2. Further, more than 200 lbs of VOCs were removed from a single extraction well during the pilot study at OU-2, which demonstrates the effectiveness of this technology.

Alternative 1, NFA, includes the continuation of the soil vapor monitoring program at OU-2, but no remedial action. Because continuation of the soil vapor sampling at OU-2 does not require construction or installation of equipment on site, potential short-term effects to workers, the public, and the environment are minimal.

Similarly, Alternative 2, SVE, presents minimal risk to workers, the public, and the environment. SVE systems are designed so that extraction wells and associated piping are under vacuum. The VOCs in the extracted air are removed by an aboveground treatment system, in accordance with state and local regulations.

The estimated present-worth cost of Alternative 1, NFA, is $1,477,000. Because Alternative 1 does not reduce the toxicity, mobility, or volume of VOCs at OU-2, it is not effective in the long term, and, therefore, is not a cost-effective alternative.

The estimated present-worth cost of Alternative 2, SVE, is $3,735,000. Because Alternative 2 is a presumptive remedy that permanently reduces the volume of VOCs at OU-2, and thus reduces future risks to groundwater, it is cost-effective in the long term.

NASA and the regulatory authorities agree that the costs associated with SVE are justified because the preferred action reduces and removes VOCs from vadose zone soil at JPL OU-2 and reduces the potential for further groundwater contamination. Thus, groundwater beneath JPL is protected, as required under both NCP (40 CFR Section 300.430(e)(2)(B)) and State of California regulations for the beneficial use of groundwater, including groundwater used as a source of drinking water.

13.4 Use of Permanent Solutions and Alternative Treatment Technologies

Alternative 1, NFA, does not meet chemical-specific ARARs and cannot meet the RAO for OU-2 because, under this alternative, VOCs are left in place at OU-2, and groundwater beneath JPL is not protected. In addition, Alternative 1 is not a treatment technology, does not reduce the toxicity, mobility, or volume of contaminants at OU-2, and is not effective over the long term, because VOCs are left in place with the potential to migrate to groundwater.

Alternative 2, SVE, the selected remedy, is a presumptive remedy that permanently removes VOCs from vadose zone soil, thus reducing the volume of contaminants at OU-2. This alternative is effective over the long term, is protective of human health and the environment, and can meet all ARARs. As an EPA presumptive remedy for sites with VOCs present in soil, SVE represents the maximum extent to which permanence and treatment can be practicably used at OU-2.

13.5 Preference for Treatment as a Principal Element

SVE can permanently remove VOCs from vadose zone soil at OU-2, and thus reduce their volume and mobility. SVE meets the CERCLA preference for treatment as a principal element.

13.6 Five-Year Review Requirements

NASA intends to remediate VOCs in vadose zone soil at JPL to prevent, to the extent practicable, further migration of VOCs to groundwater to protect an existing drinking water source. A Five-Year review will be conducted if hazardous substances, pollutants, or chemicals remain at the site above levels that allow for unlimited use and unrestricted exposure. This site and remedy review will be conducted no later than five years after the start of the remedial action (See, 42 USC 9621(c)).

14.0: DOCUMENTATION OF SIGNIFICANT CHANGES

The Proposed Plan identified Alternative 2, SVE, as the Preferred Alternative for remediation of vadose zone soil at JPL (OU-2). NASA reviewed all written and verbal comments submitted during the public comment period. It was determined by NASA, EPA, DTSC, and RWQCB that no significant changes to the remedy, as originally identified in the Proposed Plan, were necessary or appropriate.

Part III: THE RESPONSIVENESS SUMMARY

The purpose of the Responsiveness Summary is to provide an opportunity for the National Aeronautics and Space Administration (NASA) to review and respond to the public's comments, concerns, and questions about the remedial technology selected to clean up soils at the Jet Propulsion Laboratory (JPL).

NASA held three public meetings: the first on May 12, 2001, the second on May 14, 2001, and the third on June 20, 2001, to formally present the Proposed Plan (NASA, 2001) for cleanup of vadose zone soil to the community, and to answer questions and receive comments. The transcripts of these meetings are included in Appendix D of this Record of Decision (ROD). The Responsiveness Summary is organized as follows:

1.0 Overview
2.0 Background on Community Involvement
3.0 Summary of Comments Received during the Public Comment Period and Responses from NASA

Appendix G contains the Public Comments and NASA Responses.

1.0: OVERVIEW

At the time of the public comment period, NASA presented soil vapor extraction (SVE) as the preferred alternative for Operable Unit 2 (OU-2), on-facility vadose zone soil. NASA proposed utilizing SVE to remove volatile organic compounds (VOCs) from the vadose zone in order to reduce the migration of VOCs to the groundwater and to protect an existing drinking water source. No changes to the SVE alternative have been proposed in the ROD. Additionally, no changes to the preferred alternative and no new alternatives were suggested by the public during the public comment period.

Therefore, the selected remedy for the cleanup of VOCs in the vadose zone soil at JPL is SVE. SVE is a two-step process. In the first step, VOCs in soil vapor are removed from the subsurface by applying a vacuum to an underground well. In the second step, the recovered vapors are filtered out by carbon (or some other treatment process) to prevent their release to the atmosphere.

2.0: BACKGROUND ON COMMUNITY INVOLVEMENT

Initial interviews with community members in 1991 and again in 1993 indicated a relatively low level of awareness in the three surrounding communities regarding the placement of JPL on the National Priorities List (NPL) (NASA, 1994). Despite the apparent lack of awareness, people expressed a relatively high level of concern about environmental issues in general. Residents suggested using community newsletters to convey important information, in addition to the media sources NASA was already using (NASA, 1994). NASA attempted to address these concerns through community newsletters and fact sheets distributed to members of the surrounding communities.

In May and June 2001, three public meetings were held to inform the public of the remediation alternatives chosen as part of the Proposed Plan to clean up on-facility soils at JPL. The public comment period pertaining to these meetings was held May 7 through July 11, 2001. During this time, members of the public had the opportunity to comment on the information presented in the public meetings and the Proposed Plan. Comments submitted during the public comment period were collected, reviewed, and addressed as appropriate.

3.0: SUMMARY OF PUBLIC COMMENTS RECEIVED DURING THE PUBLIC COMMENT PERIOD AND RESPONSES FROM NASA

This section provides a summary of the comments received from the public during the public comment period and the responses from NASA and the regulatory agencies. Appendix G contains responses to each specific question or comment received during the comment period.

3.1 Remedial Alternative Concerns

The majority of the questions (approximately 40) requested clarification on aspects of the SVE remedial alternative that was proposed to remove VOCs from soils beneath JPL. These included requests for the remedial alternatives that were considered other than the two that were presented; a description of how the granular activated carbon (GAC) used to remove the VOCs is regenerated; clarification of the long-term monitoring plan; and the risks associated with SVE.

NASA Response: SVE, thermal desorption, and incineration are designated by the U.S. Environmental Protection Agency (EPA) as presumptive remedies for sites with VOCs in soils. A presumptive remedy is a technology that EPA believes, based upon its past experience, generally will be the most appropriate remedy for a specified type of site (EPA, 1993). Selection of a presumptive remedy allows NASA to streamline site investigation and speed up selection of cleanup actions. NASA did not select thermal desorption and incineration as alternatives for the JPL site because these options would require excavation of the VOC-impacted soil. Excavation of VOC-impacted soils is not feasible considering the large area, depth of the chemicals under investigation, and the locations of buildings/structures.

The GAC used to remove VOCs from the vapor stream is replaced with fresh GAC when it becomes saturated with VOCs. The GAC is transported off site to a certified hazardous waste facility and regenerated or disposed.

The remedial action objective (RAO) for this site is to prevent, to the extent practicable, further migration of the VOCs at potential levels of concern from the vadose zone to groundwater to protect an existing drinking water source. The monitoring program proposed as part of the SVE alternative consists of the periodic collection and analysis of soil vapor samples from soil vapor monitoring points. The soil vapor sampling frequency will either be adjusted or ended, depending on the performance of the SVE system and analysis of soil vapor concentrations.

SVE is a common, effective remediation process for the treatment of VOCs in soil. Information regarding system effectiveness will be made available throughout the operation. SVE presents minimal risks to workers, the public, or the environment. The South Coast Air Quality Management District (SCAQMD) requires that all discharges to the atmosphere meet certain standards to protect ambient air quality for the public health and welfare. Vapors extracted by the SVE process have been and will be treated as required by the SCAQMD.

3.2 Public Participation Process

Nine complaints were made that not enough notice was given between the announcement of the public meetings and the date of the public meetings held in May 2001. In addition, a comment was made regarding a missing document at one of the information repositories.

NASA Response: In response to these concerns, a third public meeting was held on June 20, 2001 to provide another opportunity for the public to comment on the Proposed Plan. The public comment period subsequently was extended to reflect the addition of the third meeting. The public comment period ran from May 7 through July 11, 2001. NASA apologizes for the short notice and has made plans to send notices of future meetings earlier to allow for better planning.

With regard to the missing document, NASA established information repositories in the public libraries of Altadena, La Cañada Flintridge, and Pasadena. NASA will maintain a copy of the administrative record at each information repository; however, the public is urged to contact one of the officials listed in the Proposed Plan if documents are missing so that replacements may be provided. NASA replaced the missing document on June 28, 2001.

3.3 Cost/Funding Issues

Seven questions were raised regarding who was paying for the cleanup at JPL and how that funding was being provided.

NASA Response: NASA is currently paying for all costs associated with the remedial investigation and work being done at JPL. Cleanup funds are included in the appropriations approved by Congress for NASA.

3.4 Decision Process

Approximately three questions were posed regarding who was being held responsible for the cleanup work at JPL and how that work was going to be carried out.

NASA Response: JPL is a federal facility owned by the federal government. NASA, however, is the executive agency responsible for administrative control of JPL. NASA is the lead federal agency for all cleanup work being done at the site. NASA is working in cooperation with the Federal EPA, the State of California Environmental Protection Agency (Cal-EPA) Department of Toxic Substances Control (DTSC), and the Regional Water Quality Control Board (RWQCB), Los Angeles Region. The Naval Facilities Engineering Command (NAVFAC) is also providing technical assistance to NASA on cleanup decisions at JPL. NAVFAC, working with NASA, selects appropriate subcontractors to provide assistance and expertise in performing the investigation and cleanup work at JPL.

3.5 VOCs and Perchlorate in Groundwater

Several questions were asked regarding VOCs and perchlorate in groundwater.

NASA Response: The Proposed Plan, under review during the public comment period extending from May 7 to July 11, 2001, concerned the remedial alternative for the vadose zone soil covered under OU-2. The Proposed Plan for groundwater issues will be presented to the public at a later date. NASA feels that the constituents of concern in the groundwater would be best addressed in detail during the public meetings for OU-1 and OU-3 after more information is available. However, an attempt has been made to address the specific questions asked during the public meetings held for OU-2. These answers may be found in Appendix G.

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